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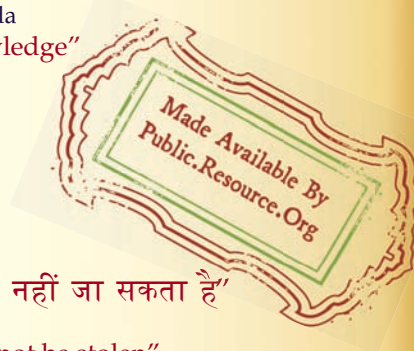
IS 14194-4 (1994): Radionuclides in environmental samples - Method of estimation, Part 4: Radium [CHD 30: Nuclear Materials]



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भारतीय मानक

पर्यावरण नमूनों में रेडियोन्यूक्लाइड्स —
आंकलन की पद्धतियां

भाग 4 रेडियम

Indian Standard

**RADIONUCLIDES IN ENVIRONMENTAL
SAMPLES — METHODS OF ESTIMATION**

PART 4 RADIUM

UDC 614'876 : 543 [546'432]

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BUREAU OF INDIAN STANDARDS
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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Nuclear Materials Sectional Committee had been approved by the Chemical Division Council.

Radium (^{226}Ra) is one of the radionuclides of importance in environmental radioactivity monitoring. These radionuclides in environmental samples are evaluated by separation and the radioactivity is measured by either of alpha, beta or gamma radiation, emitted by the radionuclides.

This method is applicable to environmental waters (sea water, drinking water) after pre-concentration, samples of biological (fishes, aquatic weeds) and mineralogical origin (ores, rocks, soil, etc), which are brought into solution by appropriate chemical methods.

Composition of the committee responsible for formulation of this standard is given at Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RADIONUCLIDES IN ENVIRONMENTAL SAMPLES — METHODS OF ESTIMATION

PART 4 RADIUM

1 SCOPE

This standard prescribes method of estimation of radium in environmental samples such as biological, mineralogical and water samples.

2 REFERENCES

The following Indian Standard is a necessary adjunct to this standard:

IS No.	Title
IS 14194 (Part 2) : 1994	Radionuclides in environmental samples — Methods of estimation: Part 2 Gross alpha activity

3 TERMINOLOGY

3.1 For the purpose of this standard the following terms shall apply.

3.1.1 *Nuclide* — A species of atom characterised by its mass number, atomic number and nuclear energy state, provided that the mean life in that state is long enough to be observable.

3.1.2 *Radionuclide* — A radioactive nuclide.

4 PRINCIPLE

In this method Radium-226 in solution is determined by storing the solution for a known period in a bubbler assembly and collecting the built-in radon gas in a scintillation cell and counting alpha activity after attaining equilibrium with radon daughters.

Radium-226 → Radon-222 → Polonium-218 → Lead-214 →
($T_{1/2}$: 1600 y) ($T_{1/2}$: 3.8 d) ($T_{1/2}$: 3.05 m) ($T_{1/2}$: 26.8 m)

Bismuth-214 → Polonium-214 → Lead-210
($T_{1/2}$: 19.7 m) ($T_{1/2}$: 10.4 s) ($T_{1/2}$: 22 y)

5 APPARATUS

5.1 **Radon Bubbler** — of 2 cm dia, 40 cm height (see Fig. 1).

5.2 **Scintillation Cell (Lucas Type)** — See Fig. 2.

5.3 **Vacuum Pump**

5.4 **Hypodermic Needle**

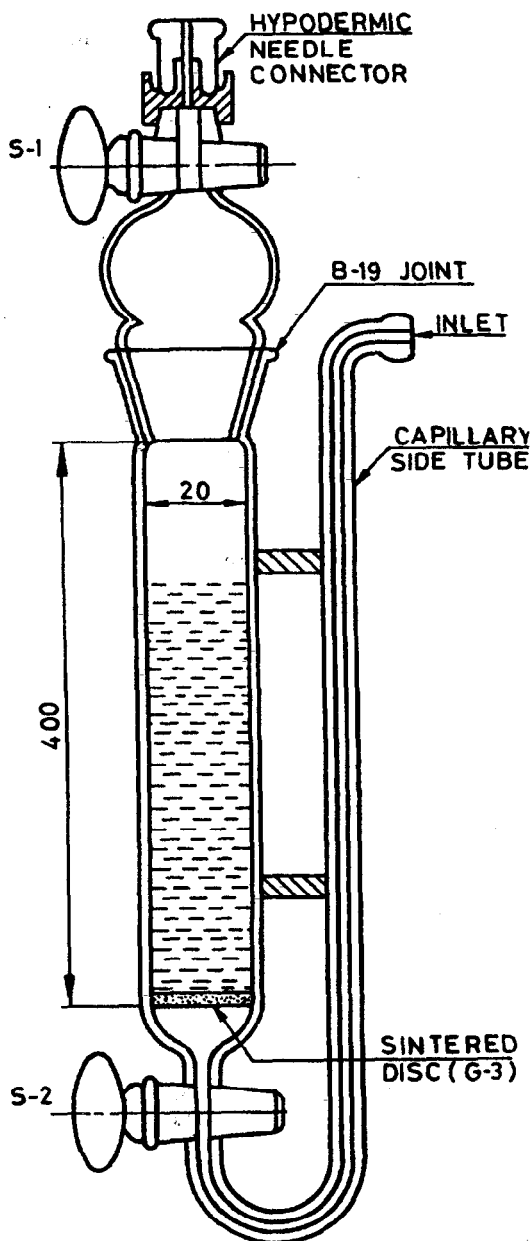


FIG. 1 RADON BUBBLER

5.5 **Alpha Counting System Consisting of High Voltage Unit**

5.6 **Timer**

5.7 **Scalar with a Photomultiplier Assembly**

6 PROCEDURE

6.1 Transfer a known volume of the sample to the radon bubbler.

6.2 Connect the vacuum pump to the bubbler and pass air through the sample to scrub the sample solution of any built in Radon-222.

6.3 At the end of the scrubbing, lasting for about 5 minutes close the stopcocks, put off the pump and disconnect the bubbler.

6.4 Leave the solution in the bubbler to stand for a known period (t_2), say about 15 days (3-5 half-lives of Radon-222) to allow sufficient build up of radon activity.

6.5 At the end of the desired radon build up period, connect an evacuated (up to 0.1 Torr) scintillation cell (Fig. 2) of a predetermined background to the bubbler through a hypodermic needle (No. 19 or 20).

6.6 Open slowly but immediately, stopcock (S1) at the top to allow entry of air carrying radon from the bubbler into the cell. Open now stopcock (S2) to admit air through the solution column, resulting in a vigorous bubbling which will ensure complete release of radon from the solution and collection of the same in the scintillation cell. Contribution from radon present in air can be neglected or corrected from blank run.

6.7 Disconnect the scintillation cell from the bubbler when radon collection appears complete (air bubbling stops). Quantitative collection of radon in the cell is indicated by a gradual decrease to ultimate stoppage of effervescence in the bubbler.

6.8 Store the radon containing cell for a known period (t_1) of about 4 hours or more to allow radon daughters to reach equilibrium with radon.

6.9 At the end of the storage period, connect the scintillation cell to the photomultiplier assembly and count the alpha activity for a period (t_3) of 10 minutes or half an hour depending on count rate observed in accordance with the method prescribed in IS 14194 (Part 2) : 1994.

6.10 The Radium-226 content of the solution in the Bubbler can be derived as follows by using the appropriate build up and decay factors for Radon-222, which is a function of the build up period and decay constant of Radon-222.

Radium-226 (Bq/ml)
for the sample in the Bubbler =

$$\frac{R_S - R_B}{R_C} \times \frac{1}{e^{-\lambda t_1}} \times \frac{1}{1 - e^{-\lambda t_2}} \times \frac{\lambda t_3}{1 - e^{-\lambda t_3}} \times \frac{1}{V}$$

where
 R_S = observed count rate of sample + background in count per hour,

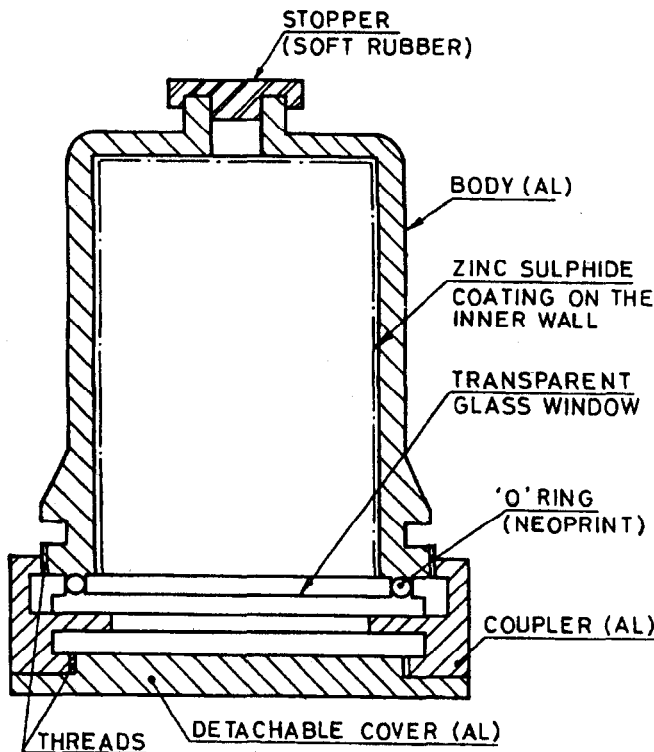


FIG. 2 SCINTILLATION CELL

- R_B = observed background count rate in count per hour,

R_C = calibration constant for the Scintillation cell (that is, observed net counts per hour corrected for growth and decay factors per Bq of ^{226}Ra Radium standard solution),

λ = decay constant for ^{222}Rn (0.007 55/hour),

t_1 = time interval between radon collection and counting in hours,

t_2 = time interval allowed for growth of ^{222}Rn in hours,

t_3 = time interval of counting in hours, and

V = volume in ml of sample solution in the Bubbler.

Radium-226 can also be derived by the following formula:

Radium-226 (Bq/ml) = $\frac{R_S - R_B}{R_C} \times \frac{C}{AB} \times \frac{1}{V}$

where

A = factor for decay of ^{222}Rn = $(e^{-\lambda_1})$,

B = factor for growth of ^{222}Rn = $(1 - e^{-\lambda_2})$, and

C = factor for correction of ^{222}Rn decay during counting period of t_3 hrs.

= $\frac{\lambda_3}{1 - e^{-\lambda_3}}$

NOTES

1 Factors A, B and C are given in Table 1 for different time intervals.

2 Calibration constant R_C has to be determined using known ^{226}Ra Radium standard solution.

Table 1 Factors for Decay of Radon 222, Growth of Radon 222 from Radium 226, and Correction of Radon 222 Activity for Decay During Counting

Time	Factor for Decay of Radon 222		Factor for Growth of Radon 222 from Radium 226		Factor for Correction of Radon 222 Activity for Decay During Counting
	$A = e^{-\lambda t_1}$		$B = 1 - e^{-\lambda t_2}$		$C = \lambda_3 / (1 - e^{-\lambda_3})$
	Hours	Days	Hours	Days	Hours
0.0	1.000 0		0.000 00		1.000
0.2	0.998 5		0.001 51		1.001
0.4	0.997 0		0.003 01		1.001
0.6	0.995 5		0.004 52		1.002
0.8	0.994 0		0.006 02		1.003
1	0.992 5	0.834 3	0.007 52	0.165 7	1.004
2	0.985 0	0.696 0	0.014 99	0.304 0	1.008
3	0.977 6	0.580 7	0.022 40	0.419 3	1.011
4	0.970 3	0.484 4	0.029 75	0.515 6	1.015
5	0.963 0	0.404 1	0.037 05	0.595 9	1.019
6	0.955 7	0.337 2	0.044 29	0.662 8	1.023
7	0.948 5	0.281 3	0.051 48	0.718 7	1.027
8	0.941 4	0.234 7	0.058 61	0.765 3	1.031
9	0.934 3	0.195 8	0.065 69	0.804 2	1.034
10	0.927 3	0.163 3	0.072 72	0.836 7	1.038
11	0.920 3	0.136 3	0.079 69	0.863 7	1.042
12	0.913 4	0.113 7	0.086 62	0.886 3	1.046
13	0.906 5	0.094 8	0.093 49	0.905 2	1.050
14	0.899 7	0.079 1	0.100 31	0.920 9	1.054
15	0.892 9	0.066 0	0.107 07	0.934 0	1.058
16	0.886 2	0.055 1	0.113 8	0.944 9	1.062
17	0.879 5	0.045 9	0.120 5	0.954 1	1.066
18	0.872 9	0.038 3	0.127 1	0.961 7	1.069
19	0.866 4	0.032 0	0.133 6	0.968 0	1.073
20	0.859 8	0.026 7	0.140 2	0.973 3	1.077
21	0.853 4	0.022 3	0.146 6	0.977 7	1.081
22	0.847 0	0.018 6	0.153 0	0.981 4	1.085
23	0.840 6	0.015 5	0.159 4	0.984 5	1.089
24	0.834 3	0.012 9	0.165 7	0.987 1	1.093
25	0.828 0	0.010 8	0.172 0	0.989 2	1.097

Table 1 (Concluded)

Time	Factor for Decay of Radon 222		Factor for Growth of Radon 222 from Radium 226		Factor for Correction of Radon 222 Activity for Decay During Counting
	$A = e^{-\lambda_1 t_1}$		$B = 1 - e^{-\lambda_2 t_2}$		$C = \lambda_2 / (1 - e^{-\lambda_2 t_3})$
	Hours	Days	Hours	Days	Hours
26	0.821 8	0.009 0	0.178 2	0.991 0	1.101
27	0.815 6	0.007 5	0.184 4	0.992 5	1.105
28	0.809 5	0.006 3	0.190 5	0.993 7	1.109
29	0.803 4	0.005 2	0.196 6	0.994 8	1.113
30	0.797 3	0.004 4	0.202 7	0.995 6	1.118
31	0.791 3	0.003 6	0.208 7	0.996 4	1.122
32	0.785 4	0.003 0	0.214 6	0.997 0	1.126
33	0.779 5	0.002 5	0.220 5	0.997 5	1.130
34	0.773 6	0.002 1	0.226 4	0.997 9	1.134
35	0.767 8	0.001 8	0.232 2	0.998 2	1.138
36	0.762 0	0.001 5	0.238 0	0.998 5	1.142
37	0.756 3	0.001 2	0.243 7	0.998 8	1.146
38	0.750 6	0.001 0	0.249 4	0.999 0	1.150
39	0.744 9	0.000 9	0.255 1	0.999 1	1.154
40	0.739 3	0.000 7	0.260 7	0.999 3	1.159
41	0.733 8	0.000 6	0.266 2	0.999 4	1.163
42	0.728 3	0.000 5	0.271 7	0.999 5	1.167
43	0.722 8	0.000 4	0.277 2	0.999 6	1.171
44	0.717 3	0.000 3	0.282 7	0.999 7	1.175
45	0.712 0	0.000 3	0.288 0	0.999 7	1.179
46	0.706 6	0.000 2	0.293 4	0.999 8	1.184
47	0.701 3	0.000 2	0.298 7	0.999 8	1.188
48	0.696 0	0.000 2	0.304 0	0.999 8	1.192
49	0.690 8	0.000 1	0.309 2	0.999 9	1.196
50	0.685 6	0.000 1	0.314 4	0.999 9	1.201
51	0.680 1	0.000 1	0.319 6	0.999 9	1.205
52	0.675 3	0.000 1	0.324 7	0.999 9	1.209
53	0.670 2	0.000 1	0.329 8	0.999 9	1.213
54	0.665 2	0.000 1	0.334 8	0.999 9	1.218
55	0.660 2	0.000 0	0.339 8	1.000 0	1.222
56	0.655 2	0.000 0	0.344 8	1.000 0	1.226
57	0.650 3	0.000 0	0.349 7	1.000 0	1.231
58	0.645 4	0.000 0	0.354 6	1.000 0	1.235
59	0.640 5	0.000 0	0.359 5	1.000 0	1.239
60	0.635 7	0.000 0	0.364 3	1.000 0	1.244

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This Indian Standard has been developed from Doc : No. CHD 030 (0590

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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